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ADP010629

TITLE: Exploratory Use of VR Technologies for Training Helicopter Deck-Landing Skills

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TITLE: The Capability of Virtual Reality to Meet Military Requirements [la Capacite de la rea1ite virtuelle a repondre aux besoins militaires]

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EXPLORATORY USE OF VR TECHNOLOGIES FOR TRAINING HELICOPTER DECK-LANDING SKILLS

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ABSTRACT

Canadian Forces (CF) pilots and landing safety officers require intensive training to develop the individual and team skills required for safe helicopter deck landings. These skills are currently acquired at sea, following individual training with independent simulators unequipped with visual displays.

DCIEM is exploring the feasibility of using commercial, off-the-shelf technologies as the essential components for simulators for training the pilot of the Sea King helicopter and the landing safety officer (LSO) of a Canadian Patrol Frigate (CPF). The objective of this project is to assess virtual reality and computer networking technologies that could be exploited in the development of a federation of interconnected, low-cost simulators. The human factors of visual and motion cueing, and coupling of the simulators, present the major technical challenges to the project's success.

This paper will describe the exploratory development models, some preliminary reactions, and the experimental plan proposed to assess the training effectiveness of the helicopter simulators.

BACKGROUND

In 1993, DCIEM completed the exploratory development of the Maritime Surface/Subsurface Virtual Reality Simulator (MARS VRS) that made use of virtual reality technologies for training ship handling skills. A low-resolution, biocular, head-mounted display was employed to provide a student officer-of-the-watch (OOW) with a view of his bridge and the surrounding environment, including other ships, so that he could acquire the skills needed to perform formation manoeuvres. Visual judgements of the ship's relative position, orientation and their rate of change guide the OOW's behaviour as do auditory communications among the bridge crew. Voice recognition was used to interface the OOW with a surrogate bridge team that responded to his spoken commands and automated voice production was used to provide orders to the student as a yeoman would normally read them aloud; different voices were used to provide the verbal information that other members of the bridge crew would normally speak aloud during the conduct of a manoeuvre. The behaviours of the other ships in the formation were guided by textbook solutions particular to the sequence of orders that formed the lesson plan.

The results of a transfer-of-training experiment, which compared the performance of students trained with the simulator for a week to the performance of students who followed the regular programme of instruction that made use of a gate vessel, indicated that the MARS VRS simulator better prepared students for formation manoeuvres when they had to perform them for the first time at sea with a mine sweeper. Simulator sickness questionnaires indicated incidence rates and severity reports similar to those of conventional aircraft simulators and tests of postural stability using a force plate found no evidence of ataxia associated with training.

On the basis of these positive outcomes, three MARS VRS simulators were later interconnected. Each was operated by a qualified officer, at widely separated locations. Although the simulators were physically apart by as many as 5000 kilometres, distributed interactive simulation permitted the officers to conduct formation manoeuvres within the virtual environment as proficiently as they would be expected to perform them at sea, where they are normally within 300 metres of each other.

HUMAN FACTORS ISSUES

The results of the transfer of training study indicate that positive transfer-of-training can be obtained with simulators using low-resolution, head-mounted displays for training visually based tasks that do not seem to demand high quality

Paper presented at the RTO HFM Workshop on "The Capability of Virtual Reality to Meet Military Requirements", held in Orlando, USA, 5-9 December 1997, and published in RTO MP-54.

imaging; ships in formation are large, slow-moving and relatively close, although simultaneously beyond the range for human stereopsis. The results of the networking trial indicate that close coupling of the simulations is not a significant concern for formation manoeuvres since the ships move slowly and the tolerances for formation manoeuvres are large (within 10 metres) relative to the spatial congruency afforded by distributed interactive simulation technologies (i.e., less than one metre).

In comparison, the deck landing tasks present greater challenges to the successful exploitation of virtual reality and interactive networking for training. The pilot of the helicopter must make accurate judgements of surface orientation and distance well within the range of stereoscopic perception. In the North Atlantic, fog will often obscure the horizon and close proximity to the hangar face will limit the pilot's ability to make visual judgements of orientation or position independent of his immediate surroundings. The relative motions between ship and helicopter will therefore present an ambiguous visual environment to the pilot, who will not likely be able on the basis of visual cues alone to determine whether the ship, for example, rolled to the left with a wave or whether the helicopter rolled to the right with air turbulence. Without physical motion cues, the landing safety officer could similarly be confronted with an ambiguous situation when he must assist the pilot in achieving an accurate touchdown. Centimetres matter, and close-coupling of the LSO's and pilot's visual environments, in time and space, seems to be a clear necessity for simulator team training. The purpose of the current efforts are to determine whether virtual reality technologies can provide the visual and motion cuing needed to perform helicopter deck landing team training, and whether the High Level Architecture, is suitable for real-time, interactive networking in this scenario.

EXPLORATORY DEVELOPMENT MODELS

In order to assess the efficacy of the available technologies three exploratory development models are being constructed. Two will simulate the Sea King helicopter; each will be linked eventually to an LSO simulator and an existing MARS VRS. The two Sea King simulators differ dramatically in the cost and complexity of their components. The first, now ready for test flights, has been developed by the University of Toronto Institute for Aerospace Studies, employing state-of-the-art (SOA) components. The second, now being integrated by DCIEM, employs commercial off-the-shelf (COTS) components. A comparison of system components is shown in Figure 1. The LSO simulator, still under development, also employs the COTS technologies identified in Figure 1.

Figure 1 - Comparison of System Components

UTIAS	DCIEM
• FOHMD	• VR4 HMD
• CAE MaxView IG	• SGI Onyx IG
• 6dof, hydrostatic motion platform	• 6dof, COTS motion platform
• McFadden force loaders	• ROMAC force actuators, maybe
• GenHel aeromodel	• GenHel aeromodel
• DREA/Fredyne sea state modelling	• DREA/Fredyne sea state modelling

EXPERIMENTAL PLANS

The experimental plan requires two sets of comparisons, relying on three groups of subjects. The first set of comparisons is a reverse transfer-of-training assessment. Once test pilots complete acceptance of the SOA simulator, a group of

qualified Sea King pilots will be invited to fly the simulator. They will make many deck landings as students would practice them at sea. The experimental conditions will not simulate the recovery systems or provide guidance from others. The task will be performed at the limits of the operational envelop for free-deck landings (i.e., at the maximum values for the combination of wind and ship motion permissible without use of the tether). A second group of helicopter pilots without deck-landing experience will be invited to learn this task by performing it in the simulator. Later, the performances of the two groups will be compared. If the SOA simulator provides an appropriate environment in which the skilled behaviour of the Sea King pilots can be exercised then they should show little learning and do well. The other group of pilots should not do as well initially, and should improve with practice.

The second set of comparisons is an intersimulator transfer study. The behaviour of a third group of helicopter pilots without previous deck landing experience at sea will be compared to the first two after they have been given training on the COTS device. If the COTS device provides an appropriate environment for learning deck landing skills, then this group of pilots ought to demonstrate positive transfer of training to the SOA simulator if it is validated by the reverse transfer-of-training comparison.

The suitability of the High Level Architecture for team training will be investigated after the transfer studies are complete.

PRELIMINARY INDICATIONS

An early version of the exploratory development model of the LSO simulator was recently used as a virtual prototype to assist naval architects in their effort to redesign the workstation that now limits the LSO's ability to view the helicopter when it makes a starboard approach to the deck of a Canadian Patrol Frigate. A VR4 head-mounted, binocular display made by Virtual Research was used to display a virtual environment generated by an Silicon Graphics Infinite Reality Engine. The computer generated imagery consisted of the howdah, Sea King, hangar and deck of the CPF. The visual representation of the howdah was matched to different plywood mockups that constrained the movements of the observers realistically. LSOs viewed animations of the Sea King as it approached and landed upon the deck. They were very positive about the potential use of the visual imagery for the deck landing tasks. This is an encouraging result since LSOs are also deck qualified pilots.